RHODIUM, GOLD AND OTHER HIGHLY SIDEROPHILE ELEMENTS IN CHONDRITES. M. Fischer-Gödde[1], F. Wombacher[1] and H. Becker[1], [1]Institut für Geologische Wissenschaften, FR Geochemie, Freie Universität Berlin, Malteserst. 74-100, Haus B, D-12249 Berlin, Germany (mafische@zedat.fu-berlin.de).

Introduction: Osmium isotopic data and concentrations of the highly siderophile elements (HSE) Re, Os, Ir, Ru, Pt and Pd, recently obtained on chondrites by isotope dilution and Carius tube digestion in reverse aqua regia [1,2] provide a resolution of some differences in the HSE composition of chondrite groups not attained by other methods. These data serve as a much improved basis for the comparison with planetary samples. Unfortunately, recent studies did not provide data for two other HSE, Rh and Au, because both elements are monoisotopic. Yet, both Rh and Au may be critical elements for (1) a comprehensive understanding of the different HSE patterns of the chondrite groups and their origin; (2) distinguishing likely lunar impactor populations during the late heavy bombardment [3]; and (3) for a complete characterization of the HSE pattern of the Earth's primitive mantle and its origin [4-6]. Here, we report abundances of Re, Ir, Ru, Pt, Pd, Rh and Au for a set of carbonaceous, ordinary, and enstatite chondrites and one R-chondrite. Differences and similarities between the different chondrite groups are discussed with particular emphasis on Rh and Au.

Analytical techniques: Sample aliquots of 50 mg were digested in reverse aqua regia using a HP asher at 320°C [7,8]. Prior to analysis, the HSE were purified on a cation exchange resin using a 0.2 M HCl-acetone mixture [9,10]. The abundances of Re, Ir, Ru, Pt and Pd were determined by isotope dilution using a mixed ^{185}Re-^{190}Os spike, and a mixed ^{191}Ir-^{99}Ru-^{194}Pt-^{105}Pd spike. Because Rh and Au are monoisotopic their abundances were determined by a combined internal/external standardisation procedure, using the abundance of ^{193}Ir as internal standard [7]. Isotopic ratios were measured by sector field ICP-MS (Element XR at FU Berlin). Accuracy and reproducibility of the method were tested by analysing several aliquots of the Smithsonian Allende reference powder (this study: Rh 185 ±11 ng/g Rh, 133 ±19 ng/g Au, n = 3), and by comparison with data obtained by other techniques such as spark source mass spectrometry (169 ng/g Rh, 161 ng/g Au [11]) and neutron activation analysis (150 ± 10 ng/g Au [12]). Total chemistry blanks were 36 pg for Re, 3 pg for Ir, 65 pg for Ru, 174 pg for Pt, 77 pg for Rh, 335 pg for Pd and 23 pg for Au.

Results: In Figure 1 (a-c) the abundances of Rh, Au and other HSE are shown normalised to mean concentrations in CI1 chondrites from [2], Rh and Au from [13]. Carbonaceous chondrites show CI like or lower Re/Ir and nearly flat HSE patterns from Ir to Pt, while Rh, Pd and Au are depleted compared to refractory HSE (Fig. 1 a). Gold, the most volatile HSE, is more depleted than Pd in CV chondrites (Allende) and enriched relative to Pd in CO chondrites (Kainsaz). Ordinary chondrites show more variation in absolute HSE abundances compared to the carbonaceous chondrites (Fig. 1 b). As noted before [2] absolute HSE abundances in ordinary chondrites decrease with decreasing metal content (H>L>LL). Rhenium is slightly enriched compared to Ir, Ru and Pt, which show flat to slightly increasing normalized abundances. As in carbonaceous chondrites, a decrease in normalized abundances occurs at Rh. In ordinary chondrites Pd may be depleted (Ochansk, St. Severin) or enriched (Mt. Tazerzait) relative to Rh, while Au is always enriched relative to Pd, Rh and Ir. The EH chondrites Abee and Indarch show HSE patterns that are similar to the patterns of Ochansk and Mt. Tazerzait, except that the EH chondrites are strongly enriched in Pd and Au relative to Rh and Ir (Fig. 1 c). The EL6 chondrite Hvittis has a nearly unfractionated HSE pattern combined with much lower HSE absolute abundances compared to other enstatite chondrites. The two chondrite samples with low metal content (St. Severin, Hvittis) show nearly flat CI like patterns, however, at lower absolute HSE abundances.

The R3.9 chondrite NWA 753 (not shown) has a unique fractionated HSE pattern where Ir is slightly depleted compared to other refractory HSE, while Rh and Au are strongly depleted relative to Pd. Fractionated HSE patterns of R chondrites have been observed before [14].

Discussion: The new Rh and Au data, along with previous high-precision HSE concentration data on whole rocks of chondrites [1,2,11,15] require the presence of at least three distinct components in order to explain their CI-normalized patterns. (1) While Os, Ir, Ru and Pt show little fractionation among different chondrite groups, Re, the most refractory HSE, is commonly enriched in ordinary and enstatite chondrites, and CI-like or depleted in carbonaceous chondrites [1,2]. This may indicate removal/addition of a high-temperature condensate during condensation of the most refractory HSE. (2) All chondrites show a sometimes substantial drop in normalized abundance between Pt and Rh (except St. Severin), suggesting the removal of a refractory metal phase from solar gas of a narrow temperature range (near 1400 K, if the 50 % equilibrium condensation temperatures of Lodders 2003 [16] are used), and likely before condensation of the major fraction of Ni and Fe occurred (< 1350 K).

(3) Most chondrites are characterized by variable enrichment or depletion of the moderately volatile elements Pd and Au, suggesting the variable presence of a component depleted in refractory siderophiles and enriched in moderately volatiles [17,18].

The relative abundances of HSE in chondrites can be used to discriminate between different chondrite groups [1,2]. Au/Ir correlates well with Pd/Ir and can be used to discriminate between different chondrite classes. The potential of Rh/Ir for discriminating between different clans of chondrites can be assessed once a larger set of Rh data is available.

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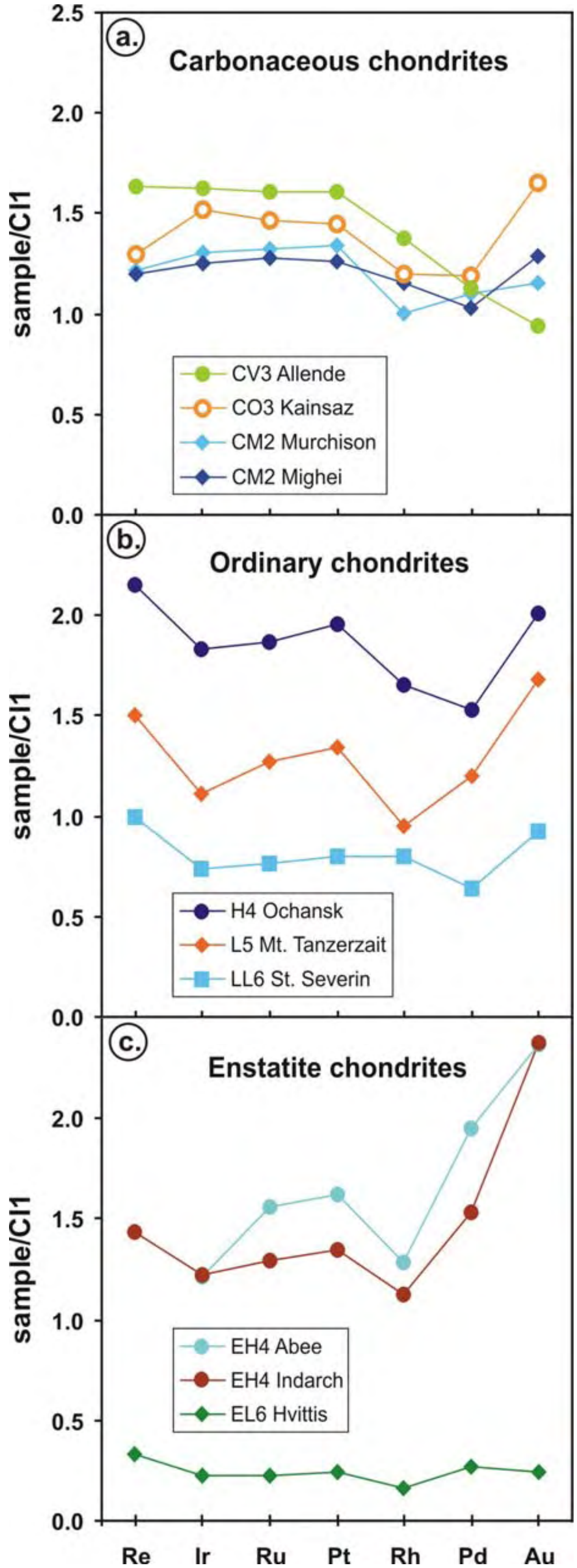

Figure 1 a-c. HSE abundances of carbonaceous, ordinary and enstatite chondrites normalized to CI1 abundances [2], Rh and Au from [13]. Elements shown in the order of decreasing 50% condensation temperature in a gas of solar-system composition [16].